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METEOROLOGY.—*The amount and vertical distribution of water vapor on clear days.* W. J. HUMPHREYS. To appear in the Bulletin of the Mount Weather Observatory.

It is of especial importance to any one using a bolometer, or a pyrheliometer, to know the approximate amount of water vapor through which the radiation reaching his instrument has passed. With the view of determining average values of this quantity the records of a large number of balloon flights have been examined, and among them 74 found that were obtained on clear days.

These have been grouped according to season, and in each case the average vertical distribution of the water vapor found. In all cases the amount of water vapor rapidly decreases with elevation; but whatever the humidity a first approximation to the average total amount of water vapor above any given level is expressed by the equation,

$$d = 2e,$$

in which d is the thickness in millimeters of the equivalent water layer, and e the partial pressure of the water vapor, at the given level, in millimeters of mercury.

OCEANOGRAPHY.—*The new Coast and Geodetic Survey tide predicting machine.* E. G. FISCHER, Coast and Geodetic Survey. Communicated by O. H. Tittman.

A noteworthy production of the mechanical department of the Coast and Geodetic Survey is the new Tide Predicting Machine. It was completed in February, 1910, and immediately, before polishing, gilding and lacquering, was put in operation for predicting all the complicated tides for the tables of 1912 and

1913. It is now dismounted and being put in a finished state for final installing in the early part of next year.

Six other machines for predicting tides now exist. The first one, designed and constructed in 1876, by Sir Wm. Thomson, later Lord Kelvin, containing 10 components, was but little used and is now on exhibition in the South Kensington Museum, London. A second one, with 20 components, was constructed in London for the British India Survey in 1879. The number of the components was later increased to 24. It has since been in use for predicting the tides of the British India ports. The third machine was constructed in 1880, by Sir Wm. Thomson. It contains 16 components, and it is supposed to be in use for the tides of the British ports. A copy of this machine was acquired by the French government in 1900 for predicting the French tide tables, and another of the same style was made for the government of Brazil about three years ago.

All these machines produce automatically a tide curve, which must be scaled off for the heights of the high and low waters, their times being taken, in the simpler tides, from hour marks upon the curve. For exact times a second curve, that representing the first derivative of the height series, must be traced and scaled off. While it takes only from two to three hours to produce a year's tide curve, several days' work is required to prepare the printer's copy from that curve.

To obtain data required for the printer from the machine direct led Prof. Wm. Ferrel of the Coast and Geodetic Survey, when the need of a tide predictor in that Bureau became imperative, to design one upon principles differing considerably from those of the English machines. In it the sine terms of the derived or time series are summed simultaneously with those of the cosine or height series, the face of the machine indicating the exact times of high or low water to be copied by the operator upon the form for the printer. For the simpler tides the heights are also taken from the face by the use of an auxiliary scale, but for the more complicated tides, the machine requires a second setting for the exact heights. This machine was constructed in 1882 and was used for preparing the tide tables of the Coast and Geo-

detic Survey from that time until 1910. It has 19 components. It produces no curve, but a record of the results is made by blueprinting the printer's copy.

Certain weaknesses and considerable wear made it desirable to provide a new machine, which should indicate upon its face, for copying directly upon the printer's form, the exact heights and times of the high and low waters, of the height of the sea at any time, and produce automatically a tide curve with hour and day marks showing the exact time of the high and low waters. Its construction was begun in 1896 and continued with many interruptions, as time could be spared from the regular work, until its completion in February, 1910.

The principles underlying the machine are the same as those of the English predictors as regards the heights. From the Ferrel machine was adopted the use of two cranks on the same component shaft: one for summing the cosine terms of the height series and the other, at right angles, for summing the sine terms of the first derivative of the former, the latter, when equal to zero, marking the times of the maxima and minima.

In order that the machine should be most comprehensive, provision was made for 37 components. The dimensions of its parts were chosen with particular view to rigidity and freedom from flexure. Workmanship and material are such as to reduce deterioration due to wear to a minimum, and the wearing parts are planned so as to permit of replacement or repair without ever interrupting the regular output of the machine. Its dimensions are: length, 10 feet 9 inches; height, 6 feet 2 inches; and width, 2 feet. The unit of height amplitude is 0.5 inch. The dial unit of height is 1 inch, 2 inches and 4 inches per foot, according to which of three scales is used. The scale of the record curve, traced on paper 6 inches wide, varies between 1:15 and 1:120, the hour being equal to $\frac{1}{2}$ inch, or the day 12 inches.

To predict a year's tides for a station takes one man from $2\frac{1}{2}$ to 4 hours according to the number of components used, for the setting of the machine, and from 8 to 15 hours, according to the complexity of the tides at the station, for copying the indicated results upon the form ready for the printer.

Tests of the machine made under severest conditions, showed agreement between predicted and computed results within 0.06 feet.

OCEANOGRAPHY.—*Note on the composition of sea water.* F. W. CLARKE and GEORGE STEIGER. Geological Survey.

Although the water of the ocean varies widely in salinity, from less than one per cent in the Baltic to as much as five per cent in the Red Sea, the composition of its saline matter is curiously constant. Innumerable analyses of it have been made, from the great oceans and the minor seas, so that this conclusion seems to be well established. Data are so far lacking, however, with regard to the waters of our own coasts, except for a single group of analyses, by A. S. Wheeler, of water from near Beaufort, N. C. In order to remedy this deficiency, Dr. A. G. Mayer of the Tortugas Laboratory of the Carnegie Institution of Washington, kindly collected a sample of water from near Loggerhead Key in the Gulf of Mexico, which was analyzed in the laboratory of the U. S. Geological Survey. The specific gravity of the water was 1.02434, at 25°, and the total salinity was 3.63516 per cent. This is slightly above the mean salinity of the ocean, 3.5 per cent. The percentage composition of the saline matter is given below, in comparison with the average composition of oceanic salts as found by Dittmar for the *Challenger* Expedition.

	GULF OF MEXICO	DITTMAR'S AVERAGE
Cl	55.24	55.292
Br	0.17	0.188
SO_4	7.54	7.692
CO_3	0.34	0.207
Na	30.80	30.593
K	1.10	1.106
Ca	1.22	1.197
Mg	3.59	3.725
	100.00	100 000

The striking similarity of the two columns is evident at a glance. The Dittmar figures are the mean of 77 analyses.

RADIO-TELEGRAPHY.—*High spark frequency in radio-telegraphy.* L. W. AUSTIN. Naval Wireless Telegraphic Laboratory.

In 1908 I published a paper[1] on the subject of the advantages of high spark frequency in radiotelography in cases where integrating detectors were used.[2] In this I called attention first to the great increase in sensitiveness of the telephone with increasing frequency, and second to the advantage to be obtained by distributing the energy of the sending station over a large number of sparks instead of concentrating it in a few. Since that time spark frequencies of approximately one thousand per second have come into common use in radiotelegraphy,[3] but the expected increase in sensitiveness of the telephone at these frequencies has not been obtained. This is illustrated by Table I which contains a comparison of the received energy as measured on a zincite rectifier[4] with galvanometer and the telephone audibility as measured with the same rectifier by the shunted telephone method. The measurements were taken at the Bureau of Standards. From this it is seen that the sensitiveness of the telephone is approximately the same for sixty cycle and five hundred cycle stations. This failure to obtain the increased sensitiveness at the higher frequency is the more remarkable, since, for sine waves at least, it has been shown independently by a number of observers.[5]

We can, however, from the data of Table I determine what the actual current sensitiveness of the telephone under wireless conditions is. We shall assume as a rough average that 1 mm.

[1] Bull. Bur. Standards, **5**: 153. 1908.

[2] Experiments have shown that the electrolytic and most of the rectifying detectors depend only on the energy.

[3] Prof. R. A. Fessenden was already experimenting with high spark frequencies at the time my paper was being written.

[4] Bull. Bureau of Standards, **7**: 295. 1911.

[5] Lord Rayleigh, Phil. Mag. **38**: 294. 1894. Wien, M., Ann. d. Phys. **4**: 450. 1901. Austin, L. W., loc. cit.

TABLE I

STATIONS	CYCLES OF GENERATOR	NATURE OF SPARK	DISTANCE, MILES	WAVE LENGTH, METERS	DEFLECTION OF GALVANOMETER D	TELEPHONE AUDIBILITY	DEFLECTION AUDIBILITY
					mm.		
U. S. S. Salem	500	Fessenden rotary	190	1000	100	77	1.3
Philadelphia Radio	500	Quenched	100	2000	220	150	1.45
New York Radio	500	Quenched	190	2200	20	18	1.1
Wilmington	60	Old type fixed	80	600	65	32	2.0
Baltimore	60	Old type fixed	35	630	130	150	0.9
Annapolis	60	Old type fixed	25	600	70	93	0.8
U. S. S. Delaware	500	Quenched		1000	7	14	0.5

deflection on the galvanometer corresponds to the least audible sound in the telephone. The sensibility of the galvanometer as used was 1.3 10^{-9} amperes per millimeter. In the work with sine waves already cited the telephones then used had a sensitiveness of 3×10^{-10} at 900 cycles and 3×10^{-7} amperes at 120 cycles. These experiments were made in a perfectly quiet room and experience has shown that the amount of current necessary to distinguish the dots and dashes under ordinary conditions in the laboratory is roughly five times this. We may therefore take the normal sensitiveness of these telephones for receiving purposes as $1.5.10^{-9}$ amperes at 900 cycles and $1.5.10^{-6}$ at 120 cycles. It is seen that the sensitiveness observed in the case of received signals both at high and low frequencies in Table I corresponds closely to the value obtained with sine waves at 900 cycles. This seems to show conclusively that the higher degree of sensitiveness is obtained with practically all transformer sparks of the types ordinarily used.[6] This might conceivably be explained either by supposing that the sparks in low frequency apparatus

[6] Possibly sparks produced by induction coils with slow moving interrupters or the infrequent sparks produced by certain forms of resonance transformers would show a decreased telephone sensitiveness.

are always multiple, thus producing more or less regular higher tones which make themselves felt in increased telephone sensitibility; or that the short sharp jerks to which the diaphragm is subjected in the case of spark discharges are more effective in moving the diaphragm than sine waves. These impulses in the case of 1000 sparks per second and a wave length of 1000 meters with 20 waves in the train last about one-seventeenth of the length of time between them if we consider that the duration of the energy is not prolonged in any way in the receiving circuit.

Regarding the second advantage of a high spark frequency, namely the distribution of the energy over a large number of sparks instead of concentrating it in a few, experience has amply demonstrated its value. In tables II and III are given the relation between spark frequency, antenna energy, antenna capacity and current for some commonly used spark frequencies.

One hundred thousand volts is considered to be the maximum which under any circumstances can be used to advantage on an

TABLE II

ANTENNA CAPACITY PER KILOWATT OF ANTENNA ENERGY

MAXIMUM ANTENNA POTENTIAL	1000 SPARKS/SECOND	120 SPARKS/SECOND
volts	*mf. per kw.*	*mf. per kw.*
50,000	0.0008	0.0067
71,000	0.0004	0.0033
100,000	0.0002	0.0017

TABLE III

ENERGY IN ANTENNA OF 0.001 MICROFARADS CAPACITY AT 50,000 VOLTS MAXIMUM POTENTIAL

SPARKS/SECOND	KILOWATTS	ANTENNA CURRENT*
		amp.
120	0.15	5
240	0.30	7.1
500	0.625	10.2
1,000	1.25	14.3

*Antenna resistance assumed to be 6 ohms.

antenna. Unless extraordinary precautions for good insulation are taken about 50,000 seems to be the most advisable limit.

RADIO-TELEGRAPHY. *The slipping contact rectifying detector.*

L. W. AUSTIN. Naval Wireless Telegraphic Laboratory.

In 1908 I described[1] a detector for electrical waves in which a bit of tellurium was pressed against an aluminum shaft in rotation. In connection with these experiments, it was found that any slipping contact if sufficiently light gave audible responses in the telephone when connected in the usual position of the detector.

Later experiments showed that this form of detector was very sensitive and extremely simple in use, requiring little adjustment, no stopping condenser and no external E. M. F., full sensitiveness being obtained with the detector simply placed in series with the secondary inductance of the receiving circuit, and a pair of telephones of from 600 to 1000 ohms resistance. The best results have been obtained by the use of a slowly rotating disk of highly polished copper or nickel driven by a spring motor, against which a bit of fine copper wire is lightly pressed.

The one difficulty which has stood in the way of the practical usefulness of this device was the obtaining of a proper surface on which the light sliding point could move, there being a tendency under most circumstances for the point to jump, thus breaking up the signal and making it difficult to distinguish the dashes from the dots. With the introduction of high spark frequency this difficulty has been to a large extent overcome, the wave trains following each other closely enough so that the dashes as heard in the telephone are invariably continuous if the adjustment is correct. When the signals are strong the musical note of the spark is reproduced in the telephone. Unfortunately, however, when they begin to weaken, the irregularities of the contact break up the musical note and it degenerates into a rustling sound which does not serve to distinguish one station from another. In sensitiveness this detector considerably surpasses any of those

[1] Electrical World, **48**: 924. 1906. Phys. Rev., **24**: 509. 1907.

now commonly used, showing itself in various tests to have an energy sensitiveness from three to ten times that of the electrolytic at minimum signal. The response as judged by the shunted telephone method is more nearly proportional to the current than to the current squared as in most other detectors.

The cause of detector action is probably complicated. There is a certain amount of true rectification as shown by a galvanometer connected in place of the telephone. This is not, however, always in the same direction, and the galvanometer sensitiveness is much less than that of the telephone. It is quite possible that the sense of the rectification changes from instant to instant and the galvanometer deflection represents merely the residual in one direction or the other. In addition to the rectifying effects it is probably that the changing contact gives rise to an action similar to that of the Poulser ticker.

RADIO-TELEGRAPHY.—*A preliminary note on the resistance of radio-telegraphic antennas.* L. W. AUSTIN. U. S. Naval Wireless Telegraphic Laboratory.

In the *Physikalische Zeitschrift* for April 15, C. Fischer published an article on the determination of antenna resistance. His method, in brief, is the substitution of an air condenser in place of the antenna and ground keeping the inductance common to both circuits and introducing resistance in the condenser circuit until the current becomes the same as that when the antenna and ground were used. This method, though I am not aware that it has ever before been published, has been in use in America for the measurement of antenna resistance since 1905 or 1906 and was I believe first suggested by R. A. Fessenden.

It has been known in a general way to many experimenters that the antenna resistance was larger at the longer wave lengths than should have been the case according to the Herzian theory of radiation.

In his article Dr. Fischer has given very interesting experimental observations and curves showing that this increase in antenna resistance is under certain circumstances proportional

to the wave length, and he appears to believe that this increased resistance is due to radiation.

Systematic measurements on the resistance of the Bureau of Standards antenna were begun as soon as Dr. Fischer's article appeared. Observations have also been taken on the antenna of the U. S. S. *Dolphin* lying at the Washington Navy Yard and on the antenna of the Navy Yard station.

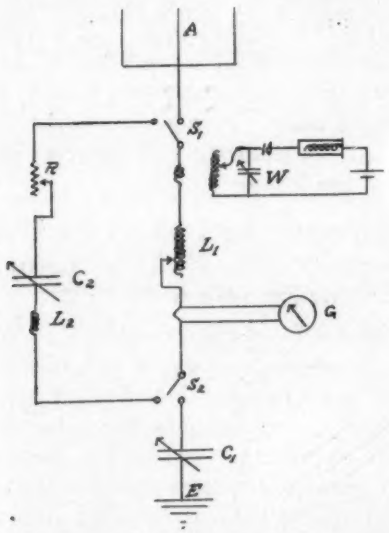

Fig. 1. Diagram of apparatus for measuring antenna resistance

The arrangement of apparatus is shown in Fig. 1. Here A is the antenna, E the ground, L_1 the tuning inductance, C_1 an air condenser for tuning to very short wave lengths, Th a thermoelement,[1] G a galvanometer and C_2 a variable air condenser set at the capacity of the antenna to be measured. A small inductance L_2 was sometimes inserted in circuit with the condenser C_2 to represent the antenna inductance. This has little influence on

[1] A zincite rectifier with galvanometer very loosely coupled to the circuit may be used instead of the thermoelement.

the results and at least for the longer wave lengths may be perfectly well omitted. S_1 and S_2 are switches for connecting either the antenna and ground or C_2 to the rest of the circuit. R is a resistance introduced in the circuit C_2 to bring down the thermo-element deflection to the same value as that observed when the antenna and ground are in circuit. The high frequency resistance consists of separate units of fine constantan wire inserted in mercury cups. The measurement circuit is excited by a buzzer-driven wave meter W of the ordinary type.

Fig. 2 shows the curves obtained on the *Dolphin*, at the Wash-

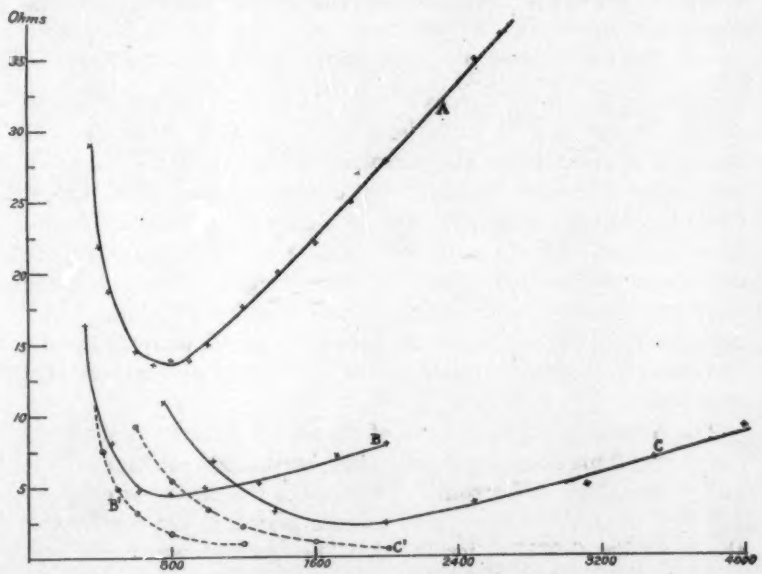

Fig. 2. Diagram showing resistance curves

ington Navy Yard and at the Bureau of Standards. It is seen that beginning with the short wave lengths, the resistance falls rapidly in accordance with the Herzian radiation theory until a point is reached which is not far from twice the fundamental wave length of the antennas.

Curve *A* is the Bureau of Standards, *B* the U. S. S. *Dolphin* and *C* the Washington Navy Yard. In curves *B* and *C* the resistance rises gradually as observed by Fischer but the rise is much slower than in his curves. The height of the flat-top antenna of the *Dolphin* is approximately 90 feet above the water, while that of the Washington Navy Yard is 150 feet. The Navy Yard has practically a water ground the station being but a few feet from the river which is moderately salt at this point. The fundamental of the *Dolphin's* antenna is 315 meters and its capacity is 0.0073 microfarad. The fundamental of the Navy Yard antenna is about 1000 meters and the capacity is 0.0036. The radiation resistance for these two antennas calculated according to the equation.[2]

$$R_r = 1600\, h^2/\lambda^2$$

is shown in the dotted curves B', C'. It is seen that the observed curves for the shorter wave lengths follow with a considerable degree of approximation the curvature of the calculated radiation resistances although the observed curves lie somewhat higher, while beyond the minimum the two curves lie far apart. We have here an indication of two factors in the resistance; one decreasing as the square of the wave length, while the other increases nearly directly as the wave length. It seems to me probable that the portion of the resistance which increases as the wave length is ground resistance, or more properly earth current resistance.

The resistance of the Bureau of Standards antenna is shown in curve *A*. This antenna is an 8-wire harp, 180 feet high at top and 60 feet high at bottom. This makes the center of capacity 120 feet from the earth. The natural period is 425 meters and the capacity 0.0012 microfarad. The ground wires are connected to the water pipes of the laboratory. It is seen that the minimum ground resistance is much higher than in the case of the *Dolphin* and Navy Yard and that the straight portion of the curve slopes more steeply upward than was the case in the other two antennas measured. It has been observed that the steepness of

[2] R. Ruedenberg, *Ann. d. Phys.*, **25**: 446. 1908.

this portion of the curve, as well as the resistance at the minimum differs by a very appreciable amount from day to day according to the dryness of the soil. On the day following a heavy rain the minimum frequently falls by two or three ohms, at the same time the resistance at a wave length of 3000 meters sometimes falls as much as ten ohms. The resistances are usually slightly higher in the afternoon than in the morning.

It is a matter of considerable interest to know toward what point the straight portion of the resistance curve descends. According to Fischer it would cross the zero axis near the fundamental, and in the curve of the Washington Navy Yard this also appears to be the case. At the Bureau of Standards, the curve of which has been taken much more accurately than any of our other observations, it appears to point toward the zero of coördinates. This may however be due to the presence of an initial ohmic resistance of about 5.5 ohms in the pipes of the ground connection.

TABLE OF RESISTANCES FOR ANTENNA

λ	G	R_T	R_T+G	OBSERVED
meters	*ohms*	*ohms*	*ohms*	*ohms*
400	5.5	13.4	18.9	22.5
600	8.0	5.9	13.9	15.0
800	11.	3.4	14.4	13.6
1000	13.5	2.1	15.6	15.2
1200	16.5	1.5	18.0	17.3
1500	21.0	0.95	22.0	21.0
2000	28.0	0.54	28.5	27.7
2500	34.5	0.34	34.8	34.5

In the table under G is given the ground resistance taken from a prolongation of the straight portion of curve A. Under R_r is given the calculated radiation resistance, from the Ruedenberg formula, while in the last two columns are given the sum of these resistances and the observed values of the curve. For most of the observations embodied in Fig. 2, I am indebted to my assistants Meneratti and Scanlin, Chief Electricians, U. S. N.

ELECTRICITY.—*Formulas and tables for the calculation of mutual and self inductance.* (Revised.) E. B. ROSA and F. W. GROVER. To appear in the Bulletin of the Bureau of Standards, **8**: 1–237. 1911.

With the increase in the precision demanded in electrical measurements, and in the standardization of electrical apparatus, and more especially in the determination of the fundamental units in absolute measure, there has arisen the necessity for more and more precise standards of mutual and self inductance, whose values may be calculated from their dimensions.

For example, in the calibration of working standards of self and mutual inductance, the values are very conveniently referred to those of absolute standards, consisting of windings of bare or enamelled wire wound uniformly on accurately turned forms of marble or other suitable non-magnetic material. The formulas for the calculation of the constants of such standards from their dimensions should be capable of at least the precision attainable in the measurement of the dimensions of the coil and the pitch of its winding.

In the most accurate methods employed for the absolute measurement of resistance and for the absolute measurement of current by means of a current balance, it is required that the value of a standard of mutual inductance may be calculated to about one part in one hundred thousand.

In magnetic measurements and in wireless telegraphy, a knowledge of the calculated value of a mutual or self inductance is often requisite, although in these cases a smaller degree of precision is sufficient.

The problem of the calculation of inductance received considerable attention as early as Maxwell's time, with the result that the constants of the simpler forms, such as circles, solenoids, and coils whose cross-section is not too large relatively to the radii, were calculated with fair precision. Some of these solutions are absolute formulas, involving elliptic integrals; others are expressed as infinite series, the number of terms requisite being governed by the precision desired, and the degree of convergence of the formula for the case in question.

For numerical calculation, the absolute formulas have the disadvantage that the inductance is given by the difference of two nearly equal terms, each of which is many times larger than the desired quantity. In such cases, each term must be calculated with greater precision than is required in the result. Series formulas, on the other hand, exhibit a satisfactory degree of convergence over a more or less limited range only, two or more series formulas being, as a rule, necessary to cover the same ground as a single absolute formula.

It thus occurs that several formulas are available in almost every case, and the question naturally presents itself as to what criterion may be applied to aid in the selection of a suitable formula for the solution of a given problem, and which is the more reliable when their results do not agree.

It was to furnish an answer to these questions that Messrs. Rosa and Cohen undertook, in 1906–07, a critical examination of all the existing formulas which had come to their notice. In the course of this investigation, certain formulas were found to be in error or capable of giving approximate values only, others were extended by them so as to give more accurate results, and in addition many new formulas were derived. These results appeared in a series of papers in the *Bulletin of the Bureau of Standards.*

At the conclusion of the work, a compilation was made of all those formulas which had been shown to be suitable for numerical calculation, together with auxiliary tables of elliptic integrals and other constants useful in such calculations. The work was divided into nine sections, treating of the mutual and self inductance of coaxial circles, solenoids, and coils of rectangular cross-section and of linear conductors, together with a chapter on geometric and arithmetic mean distances. A special feature was a collection of examples so chosen as to provide an illustration of the various formulas, and to show the agreement and relative degree of convergence of the different formulas applicable to the same problem.

Since the appearance of this collection of formulas in 1907, a number of new formulas have appeared, and the edition becom-

ing exhausted, a thorough revision was undertaken. In the second edition the same general plan and division into sections has been adhered to, with the difference that each example now appears in the section to which it applies. Considerable new material has been introduced into the sections on the mutual inductance of coaxial circles, the mutual inductance of coaxial solenoids, and the self inductance of solenoids, and a new section has been added, treating of the change of the inductance and resistance of straight cylindrical wires with change in the frequency of the current.

Of the new tables appearing in this edition, may be noted especially Nagaoka's tables for the calculation of the correction which must be applied to the self inductance of a solenoid to take account of the effect of the ends, and the tables for calculating the change of inductance and resistance with the frequency.

A number of new examples have been introduced, in connection with the new formulas, special attention having been given to the agreement of the different formulas and the checking of the results, and to aid in the selection of suitable formulas for any given problem. A portion of each section has been devoted to a discussion of the points of advantage and range of applicability of each of the formulas therein given.

This collection is intended primarily for work of the highest precision, and the formulas are consequently often more elaborate than will be required in much work of moderate precision. In such cases the calculation may be considerably simplified by carrying out the values of the various quantities to a smaller number of places of decimals, and by the retention of a smaller number of terms in the series formulas. The authors have in contemplation the preparation of a collection of approximate formulas for work of less precision.

CHEMISTRY.—*The melting points of the chemical elements.* GEORGE K. BURGESS, Bureau of Standards.

There has been much work done recently in the more exact location of some of these fixed points. The accompanying

table represents an attempt to assign the most probable values to the several melting points from a consideration of all the data available, and is a revision of the list in the new Smithsonian *Physical Tables.*

In so far as possible, the values are reduced to a common temperature scale, that given by the gas thermometer. In general, differences between the various gas scales as recently determined and the thermodynamic scale are less than the uncertainties of reproducibility by any one method. For example, the four observations on the melting point of gold, by the constant volume nitrogen thermometer, published within the past ten years, range from 1059.3° to 1067.2° C., and the correction to the thermodynamic scale is here 1° or less. Besides the direct gas thermometer determinations, there are, also, for many of the melting points, precise, differential checks made by electrical resistance, thermo-electric, or optical thermometers. The difference between the melting points of gold and copper is thus known to be 20° C. by auxiliary methods more closely than these temperatures have usually been independently located by the gas thermometer.

For the range 100° to 500° C, the scale here adopted agrees with the value 444.7 for the sulphur boiling point, a temperature that has been many times determined, and which is perhaps the best known fixed point above 300°.

For high temperatures, the scale is satisfied very exactly by taking $c_2 = 14{,}500$ in the formula for Wien's law connecting I, monochromatic luminous intensity, and T, absolute temperature: $\log I/I_1 = c_2 \lambda \log e\ (1/T_1 - 1/T)$. This agrees well with the gas thermometer measurements of Day and Sosman in the range 1000° to 1550° C. The use of Wien's law possesses the theoretical advantage for extrapolation beyond 1550° in giving the thermodynamic scale.

In the table, elements whose melting points are well known or used as standards are printed in capitals. An idea of the exactness of our knowledge of some of the melting points is also given.

MELTING POINTS (C) OF THE CHEMICAL ELEMENTS

ELEMENT	MELTING POINT	REMARKS
Helium	<−269?	B.P. He = − 268.5 Kamerlingh-Onnes
Hydrogen	−259	Travers-Jaquerod
Neon	−253?	
Oxygen	−230?	Range −227 to −235
Fluorine	−223	Moissan-Dewar
Nitrogen	−210.5	Fischer-Alt
Argon	−188	Ramsay-Travers
Krypton	−169	Ramsay-Travers
Xenon	−140	Ramsay-Travers
Chlorine	−101.5	Johnson-McIntosh
MERCURY	−38.7 ± 0.5	
Bromine	−7.3	Range—7.5 to−7.0
Caesium	26	Range 25.3 to 26.5
Gallium	30.1	Lecoq-Boisbaudran
Rubidium	38	Range 37.8 to 38.5
Phosphorus	44.1	Hulett
POTASSIUM	62.3±0.2	
Sodium	97.5±1.0	
Iodine	114±1	
Sulphur	113.5 to 119.5	Various forms
Indium	154.5±0.5	
Lithium	186	Kahlbaum
Selenium	217 to 220	Various forms. Saunders
TIN	231.9±0.2	
Bismuth	270	Range 267.5 to 271.5
Thallium	302±1	
CADMIUM	321.0±0.2	Range 320.0 to 321.7
LEAD	327.4±0.4	
ZINC	419.3±0.3	Range 418.2 to 419.4
Tellurium	451±1	
Arsenic	500	Guntz-Broniewski
ANTIMONY	630±1	"Kahlbaum" purity only
Cerium	645?	
Magnesium	650±2	
ALUMINIUM	658±1	
Calcium	805±5	
Lanthanum	810?	Muthmann-Weiss
Strontium	>Ca,<Ba?	

MELTING POINTS (C) OF THE CHEMICAL ELEMENTS

ELEMENT	MELTING POINT	REMARKS
Neodymium	840?	Muthmann–Weiss
Barium	850	Guntz
Germanium	<Ag	Winkler
Praeseodymium	940?	Muthmann–Weiss
SILVER	961±2	
Radium	600 to 1200?	Unknown
GOLD	1063±3	
COPPER	1083±3	
Manganese	1225±15	
Yttrium	1000 to 1400?	Unknown
Samarium	1300 to 1400	Muthmann–Weiss
Scandium	1000 to 1400?	Unknown
Silicon	1420±15	
NICKEL	1450±10	Day-Sosman = 1452
Cobalt	1490	Day-Sosman
Chromium	1505±15	
IRON	1520±15	
PALLADIUM	1550±15	Day–Sosman = 1549
Zirconium	> Silicon	Troost
Thorium	>1700, < Pt	Wartenberg
Vanadium	1730±30	
PLATINUM	1755±20	Waidner–Burgess = 1753
Beryllium	>1800	Parsons
Ytterbium	1600 to 2000?	Unknown
Titanium	2200 to 2400?	Weiss-Kaiser
	1800 to 1850	Hunter
Rhodium	1920?	Range 1907 to 1970
Ruthenium	>1950	Joly
Niobium	2200?	v. Bolton = 1950
Boron	2200 to 2500	Weintraub
Iridium	2300?	Range 2100 to 2350
Uranium	near Mo	Moissan
Molybdenum	2500?	Range 2110 to > 2500
Osmium	2700?	Waidner–Burgess
Tantalum	2900	Waidner–Burgess
TUNGSTEN	3000±100	Range 2575 to 3250 Waidner–Burgess = 3080
Carbon	?	Unknown

ELECTRO-CHEMISTRY.—*Thermodynamics of concentration cells.* HENRY S. CARHART. Communicated by E. B. Rosa. To appear in the Bulletin of the Bureau of Standards.

The equation $A = H + \frac{dA}{dT}$ may be considered as a very general expression of the laws of thermodynamics for isothermal processes. For the E. M. F. of a voltaic cell, this may be put in the more specific form of the Helmholtz equation $E = \frac{H}{nF} + T\frac{dE}{dT}$.

We may emphasize the two following cases: *first*, when H, the change in internal energy, is a constant. dA/dT or dE/dT is then zero, and the relation between A or E and the absolute temperature T is linear; *second*, an examination of Nernst's expressions for A and H in terms of the integral powers of T. These are according to Nernst

$$A = A_0 - bT^2 - \tfrac{1}{2}cT^3 - \ldots$$
$$H = H_0 + bT^2 + cT^3 + \ldots$$

Nernst makes the coefficient of the first power of T in the expression for A necessarily equal to zero. It is easily shown, however, that this coefficient is not zero from a mathematical point of view.

We have made an experimental investigation of the E. M. F. of various concentration cells with amalgams of different concentration as the electrodes. In every case a linear relation is established between the E. M. F. and temperature. The expression for the E then has the form $E = E_h + aT$, where E_h is the E. M. F. due to the internal change of energy H. The coefficient a is not zero as Nernst assumed it to be.

For the zinc amalgams used the equation expressing the E. M. F. is

$$E = -0.001455 + 0.00003084T$$

and the following table shows how nearly the E. M. F. as computed from this equation correspond with the observed ones:

TEMPERATURE	OBS. E.M.F.	COMP. E.M.F.	PER CENT DIFFERENCE
11.1°	0.007300	0.007307	+0.10
15.4	0.007444	0.007439	−0.07
19.8	0.007574	0.007575	+0.01
24.6	0.007720	0.007723	+0.04
29.4	0.007870	0.007871	+0.01
32.8	0.007983	0.007976	−0.09
36.6	0.008086	0.008094	+0.10
42.0	0.008262	0.008259	−0.04
47.0	0.008417	0.008414	−0.04

Electrolytic thermoelectromotive forces were measured also and showed a linear relation over a range of temperatures as much as 25 or 30°.

We have constructed two calomel cells, one with a positive temperature coefficient and the other with an equal negative one. The two cells are identical except that the former is set up with a 10 per cent zinc amalgam, and the latter with one of about 0.8 per cent. When the two cells are joined in series, the sum of their electromotive forces is independent of temperature through at least the range 8° to 34° C.

INORGANIC CHEMISTRY.—*The Fractional Precipitation of Carbonates.* ROGER C. WELLS. Geological Survey. Communicated by F. W. Clarke.

In a recent paper I described experiments upon the fractional precipitation of sulphides and pointed out that the results were in accord with what would be expected from our knowledge of the solubilities of the sulphides in water.[1] In the experiments with the sulphides fractionations were carried out with mixtures of two metallic salts in various proportions. Similar experiments are now being conducted with carbonates. Some preliminary results are presented here for mixtures containing equivalent quantities of each metallic salt. Full data and discussion are reserved for a later paper.

The procedure in these experiments was simple. A dilute solution containing two metallic salts in equivalent quantities was

[1] Econ. Geol. 5; 1. 1911.

precipitated by sodium carbonate enough for one metal only. After a time an aliquot portion of the mother liquor was analyzed and thus the composition of the precipitate determined by difference.

Since the experiments were intended to apply to the chemistry of ore deposition it was desired to find out the *final* effect. It was shown by some of the earlier results that the immediate action consists in a precipitation of both metals in nearly equivalent quantities, and that one of them proceeds to dissolve, the other

TABLE I

FRACTIONAL PRECIPITATIONS

EXPERIMENT	TAKEN, MILLI-EQ. PER LITER		DURATION OF EXPERIMENT	FOUND IN PRECIPITATE	
			days		
4	8 $ZnSO_4$	8 $CaSO_4$	17	6.52 Zn	tr. Ca
5	20 $CdSO_4$	20 $ZnSO_4$	19	15.5 Cd	4.5 Zn
6	10 $FeSO_4$	10 $CaSO_4$	3	6.25 Fe	tr. Ca
7	10 $CuSO_4$	10 $FeSO_4$	2	5.30 Cu	5.35 Fe
8	8 $CuSO_4$	8 $ZnSO_4$	26	6.84 Cu	0.76 Zn
22	8 $Pb(NO_3)_2$	8 $AgNO_3$	4	8.00 Pb	0.08 Ag
23	8 $Pb(NO_3)_2$	8 $Cd(NO_3)_2$	6	8.00 Pb	0.42 Cd
24	8 $Zn(NO_3)_2$	8 $Pb(NO_3)_2$	6	7.96 Pb	tr. Zn
25	8 $AgNO_3$	8 $HgNO_3$	24	2.28 Ag	7.98 Hg
26	8 $AgNO_3$	8 $Cd(NO_3)_2$	4	0.30 Ag	7.18 Cd
27	8 $ZnSO_4$	8 $NiSO_4$	10	5.00 Zn	1.50 Ni
28	8 $AgNO_3$	8 $Zn(NO_3)_2$	8	1.60 Ag	3.96 Zn
29	8 $FeSO_4$	8 $NiSO_4$	1	4.20 Fe	3.06 Ni
30	8 $FeSO_4$	8 $Zn(NO_3)_2$	1	2.66 Fe	2.64 Zn
31	8 $Cd(NO_3)_2$	8 $HgNO_3$	11	3.54 Cd	7.36 Hg
32	8 $MnSO_4$	8 $CaSO_4$	2	6.56 Mn	1.64 Ca
33	8 $NiSO_4$	14.54 $MgSO_4$	5	5.94 Ni	tr. Mg
34	8 $NiSO_4$	8 $MnSO_4$	9	4.04 Ni	3.80 Mn
39	8 $AgNO_3$	8 $MnSO_4$	7	3.98 Ni	5.76 Mn
40					
41	8 $AgNO_3$	8 $CaSO4$	7	6.80 Ag	1.56 Ca
42	8 $CaSO_4$	8 $MgSO_4$	8	1.60 Ca	1.12 Mg
60	8 $CuSO_4$	8 $CdSO_4$	8	7.24 Cu	0.20 Cd
64	8 $NiSO_4$	8 $AgNO_3$	6	3.16 Ni	2.96 Ag
71	16 $ZnSO_4$	16 $MnSO_4$	18 hrs.	11.96 Zn	8.96 Mn
74	16 $MnSO_4$	16 $CaSO_4$	1 hr.	14.80 Mn	5.70 Ca
78	8 $ZnSO_4$	8 $CdSO_4$	15	1.26 Zn	2.34 Cd

TABLE II

PRECIPITATION SERIES AND RELATIVE PRECIPITATIONS

EXPERIMENT	MAJOR CONSTITUENT OF PRECIPITATE	MINOR CONSTITUENT OF PRECIPITATE	RATIO OF MAJOR TO MINOR CONSTITUENT
55	Hg	Pb	Large
31	Hg	Cd	2.1
25	Hg	Ag	3.5
59	Pb	Cu	Large
23	Pb	Cd	19.0
24	Pb	Zn	Large
22	Pb	Ag	100
7	Cu	Fe	1.0
8	Cu	Zn	9.0
60	Cu	Cd	36.0
78	Cd	Zn	1.9
67	Cd	Ni	2.8
26	Cd	Ag	25.0
28	Zn	Ag	2.5
27	Zn	Ni	3.3
4	Zn	Ca	6.5
71	Zn	Mn	1.3
7	Fe	Cu	1.0
30	Fe	Zn	1.0
29	Fe	Ni	1.4
6	Fe	Ca	6.3
34	Ni	Mn	1.1
33	Ni	Mg	Large
64	Ni	Ag	1.1
32, 74	Mn	Ca	4.0
41	Ag	Ca	4.4
42	Ca	Mg	1.4

to precipitate, with the lapse of time. The change goes on for several days at the ordinary temperature, accompanied by a gradual transformation of the precipitate from a flocculent to a

more or less crystalline state. The bottles containing the solution and precipitates were allowed to stand as long as desired, with occasional shaking, in the laboratory at about 20°. There is no doubt that some of the precipitates were basic but this would make no difference as far as the application to geochemistry is concerned, for, many such salts are well known as minerals.

In the results below the concentrations are expressed in milli-equivalents per liter, an equivalent being equal in grams to the molecular weight of the metal or radicle reduced to a univalent basis. Where a liter of solution was not employed the results have been calculated to that dilution. The amount of sodium carbonate used was sufficient to precipitate all of one metal only. The results are given in Table I.

When the results in Table I are considered it is seen that in general the separation is not complete. The metals may be arranged in a series, however, such that the first one is precipitated to a greater extent than the next and so on. The completeness of the fractionation is greater as the metals are more widely separated in the series, as is shown in Table II. In some cases special reactions occur as, for example, the reduction of silver salts by ferrous and manganous salts, and these experiments are omitted.

Altho it is incorrect to state that the series represents the order of solubility of the carbonates it does represent the order of the precipitating power of carbonates upon metallic salts under similar conditions. The order is Hg, Pb, Cu, Cd, Zn, Fe, Ni, Mn, Ag, Ca, Mg. The most striking fact, perhaps, is the position of silver which is found between manganese and calcium.

The effect of bicarbonates and of higher temperatures is under investigation.

MINERALOGY.—*Ferritungstite, a new mineral.* WALDEMAR T. SCHALLER. Geological Survey. To appear in the American Journal of Science.

The new mineral *ferritungstite* is a hydrous ferric tungstate formed by the oxidation of wolframite, with which it occurs in pure and crystalline form as minute hexagonal scales, in the Ger-

mania Tungsten Mine, Washington. The yellow to brownish-yellow mineral is decomposed by acids, yellow oxide of tungsten separating out.

Analyses of two samples from the same specimen gave:

	1	2	RATIOS 1	RATIOS 2
WO_3	37.1	35.8	.94	.88
Fe_2O_3	26.6	27.3	1.00	1.00
H_2O (Ign.)	18.6	20.9	6.06	6.82
Insoluble	14.7	[16.0]		
	97.0	100.0		

The formula deduced is $Fe_2O_3 . WO_3 . 6H_2O$.

MINERALOGY—*Hinsdalite, a new mineral.* E. S. LARSEN and W. T. SCHALLER. Geological Survey. To appear in the American Journal of Science.

Hinsdalite was first collected (by E. S. L.) from the dump at the mouth of one of the tunnels of the Golden Fleece mine, near Lake City, Hinsdale County, Colorado where it is abundant as an original vein mineral associated with quartz and a little pyrite, galena, tetrahedrite, and barite. It occurs in bands an inch or so across and as crystals imbedded in granular quartz.

The crystals are either rhombohedrons, resembling cubes, or pseudo-hexagonal tablets. The angle rr' is about 91.3° from which the value 1.268 is calculated for the c axis. If the apparent hexagonal base be taken as the true base, there is a perfect basal cleavage, but the cleavage faces are nearly all wavy and striated. The optical data indicate that the mineral is only pseudo-hexagonal. The hardness is about 5; the luster is vitreous to greasy. The fresh mineral is pale greenish, but much of the material is dark grey from inclusions. The streak is colorless.

The indices of refraction are somewhat variable but the values for the principal zones are about $\alpha = 1.670$, $\beta = 1.671$, $\gamma = 1.688$. Sections normal to the cleavage show parallel extinction, while those parallel to the cleavage are in many cases hexagonal in

outline and show the emergence of the positive acute bisectrix. They may easily be taken for uniaxial crystals, as the axial angle is small but variable. 2E is usually about 32°. Basal sections of some of the crystals are divided into six radial segments and the plane of the optic axis in each segment is normal to the pseudo-hexagonal prism edge.

The following analysis was made on fresh, light gray crystals of *hinsdalite*. They were examined microscopically and found to be very pure but showed a slight zonal growth.

Analysis of hinsdalite

W. T. Schaller, analyst

PbO	31.75	1.93 or 2
SrO	3.11	
Al_2O_3	26.47	2.92 or 3
SO_3	14.13	1.99 or 2
P_2O_5	14.50	1.14 or 1
H_2O	10.25	6.40 or 6

CaO, MgO, Na_2O, K_2O traces. Density = 3.64.

Formula 2 (Pb, Sr) $0.3Al_2O_3.P_2O_5,2SO_3.6H_2O$.

Hinsdalite is infusible but whitens on heating. It reacts for aluminum when heated with cobalt nitrate, and readily yields a button of metallic lead. The water is driven off only at a temperature of from about 400° to 600° C. It is insoluble in acids. From its chemical composition and crystallographical form it is seen to be closely related to svanbergite and forms an additional member of the alunite-beudantite group.

MINERALOGY.—*Beaverite, a new mineral.* B. S. BUTLER and W. T. SCHALLER. Geological Survey. To appear in the American Journal of Science.

The new mineral *beaverite*, a hydrous sulphate of copper, lead, and ferric iron, was found (by B. S. B.) in the Horn Silver mine near Frisco, Beaver County, Utah. The mineralization occurs along a fault that has thrown Tertiary lavas down against Cambro-Ordovician limestone. The ore is mainly a replacement of the volcanic rocks.

The principal primary minerals of the deposit are galena,

sphalerite, wurtzite, pyrite, chalcopyrite, jamesonite (?), pyrargyrite, argentite, quartz, barite, sericite, and small amounts of other minerals.

To a depth of about 600 feet the primary minerals have been almost entirely altered by descending solutions and this alteration has taken place to a lesser extent to a much greater depth. The characteristic alteration is to sulphates with some secondary carbonates, chlorides, and sulphides.

The following secondary minerals have been recognized: Anglesite, cerusite plumbojarosite, jarosite, *beaverite*, linarite, bindheimite (?), smithsonite, calamine, goslarite, covellite, chalcocite, brochantite, malachite, azurite, chrysocolla, chalcanthite, cerargyrite, sulphur, chalcedony, kaolinite, gypsum, hydrous oxide of iron and manganese, and alunite (?).

Beaverite commonly occurs mixed with other secondary minerals but occasionally is found pure in small, friable masses. It is canary yellow in color and crystallizes in six-sided plates too small for measurement of the angle or determination of the optical character. Minute inclusions, whose character has not been determined, are present in nearly every crystal.

The mineral is soluble in boiling hydrochloric acid leaving an insoluble silicious residue. The analysis and ratios are as follows:

Analysis of beaverite

W. T. Schaller, analyst

Insoluble	10.05		
CuO	9.70	0.121	.92 or 1
PbO	29.44	0.132	1.00 or 1
Fe_2O_3	17.28	0.108 } .144	1.07 or 1
Al_2O_3	3.64	0.036 }	
SO_3	21.32	0.266	2.01 or 2
H_2O	9.02	0.501	3.80 or 4
	100.45		

The ratios agree well with the formula $CuO.PbO.Fe_2O_3.2SO_3.4H_2O$. The water is all constitutional as none was driven off below 250°. There is no known mineral to which beaverite is related so that at present it stands as an isolated member of the sulphate group.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*Free air data at Mount Weather for October, November, and December, 1910.* Bulletin of the Mount Weather Observatory, 3: 304–346. 1911.

During this period of 92 days, 85 kite and 7 captive balloon ascensions were made at Mount Weather, Virginia. The average height attained was 3115 meters above sea-level. The temperature, relative humidity, direction and velocity of the wind were all obtained at numerous levels and are given both in tabular form for each flight and graphically for each half month. W. J. HUMPHREYS.

METEOROLOGY.—*Temperature departures, monthly and annual, in the United States, January, 1873, to June, 1909, inclusive.* Bulletin U. S. Weather Bureau. 1911.

The 474 separate charts of this bulletin show the departure from the normal of the mean monthly and mean annual temperatures of the United States for the period, January 1873, to June 1909, inclusive, one for each month and one for each year.

Beginning with the issue for July, 1909, similar charts have appeared in each number of the Monthly Weather Review, so that the series is now complete from January, 1873, to date. W. J. HUMPHREYS.

METEOROLOGY.—*Frost data of the United States; and length of the crop-growing season.* P. C. DAY. Bulletin U. S. Weather Bureau No. 5. 1911.

This bulletin consists essentially of five large charts that show, graphically, certain climatological data of vital importance, namely: (1) The average date of the last killing frost in spring. (2) The average date of the first killing frost in autumn. (3) The latest date on which

a killing frost has occurred in spring. (4) The earliest date on which a killing frost has occurred in autumn. (5) The average length of the crop growing season, or the number of days between the average date of the last killing frost in spring and the first killing frost in autumn.

The data consist of the 10 to 30 year records of about one thousand country stations, and, therefore, being free from city disturbances, are of especial climatological value. W. J. HUMPHREYS.

METEOROLOGY.—*The Aleutian and Icelandic lows.* W. J. HUMPHREYS. Bulletin of the Mount Weather Observatory, 4. 1911.

The high regions of Greenland and Iceland are perpetually ice covered and perpetually cold. Hence at their level the air is, in general, warmer over the intervening ocean than over the land. There must therefore exist a nearly continuous atmospheric overflow from above the ocean onto these two land areas and a drainage in turn of the air from them to the water. But this is the nature of a cyclonic circulation, and therefore this region is almost continuously surrounded by counterclockwise winds of varying intensity.

A similar temperature distribution, with its resulting cyclonic winds, obtains during the winter in the neighborhood of the Aleutian islands. But the Siberian and Alaskan peninsulas, since their elevation is small, are relatively warm in summer and hence the Aleutian low is only a seasonal phemonenon.

With the exception of the polar regions, in contrast with the equatorial, there are no other places with such pronounced and, at the same time, so continuous temperature gradients to either side of them, and therefore no other permanent or semipermanent low. W. J. H.

METEOROLOGY.—*Vertical temperature gradients and convection limits.* W. J. HUMPHREYS. Bulletin of the Mount Weather Observatory, 4. 1911.

By day the surface layer of the air is warmed mainly by contact with the heated earth, and the layers next above by convection. Hence the afternoon temperature gradient must closely follow first, the dry air adiabat, and then, if convection has extended high enough, the saturation adiabat.

By night the lowest air is cooled by contact with the relatively cold earth, and the layers next above partly through mixture with the cooler under air and partly by radiation, and thus an inversion gradient—one that shows warming with elevation—is often produced near the surface.

Hence the average gradient departs more and more from the adiabats as the surface is approached. These deductions are fully supported by the temperature records of sounding balloons.

Morning convections, therefore, necessarily are shallow, since the dynamic cooling of the rising air quickly brings its temperature to or below that of the surrounding atmosphere. The same conditions also limit the height of the afternoon convections, though these generally attain to greater elevations than do those of the forenoon. W. J. H.

METEOROLOGY.—*Some weather proverbs and their justification.* W. J. HUMPHREYS, Weather Bureau. Popular Science Monthly, **78**: 428–444. 1911.

A large number of weather proverbs dealing with the colors of the sky, haloes, coronas, clouds and other natural phenomena are given, and both their causes and relation to weather changes explained in non-technical terms.

Only these proverbs are quoted that concern natural phenomena and which have more or less scientific justification for the predictions they make. W. J. H.

OCEANOGRAPHY.—*Arctic tides.* ROLLIN A. HARRIS. 103 pp. 2 figs. and map. Government Printing Office. 1911.

In preparing this paper, which gives in detail the observations by the Peary expedition, 1908–1909, and by the expedition under Mikkelsen and Leffingwell, 1906–1907, one of the principal aims has been to bring together all available results pertaining to tides in Arctic waters. Scientifically, the most important of these is probably the table of harmonic constants for 50 stations, all but one of which lie north of the 60th parallel. The lunitidal intervals and ranges of tide are given for more than 200 points or stations in the Arctic Regions. The mean range of tide varies from 23 feet in Ashe Inlet, Hudson Strait, to 0.2 foot at Pitlekaj, on the Siberian coast not far west of Bering Strait.

A cotidal map shows the times and ranges of the semidaily tide, so far as known, and the estimated times in regions where no observations have been taken. The semidaily tides of the Arctic Ocean are derived almost entirely from those of the Atlantic; for, the semidaily tidal forces are small in high latitudes and vanish at the Pole. Hence the extensive progressions from the Atlantic into and over the Arctic. Five "no-tide points," or points where the range of the semidaily tide becomes zero, are indicated upon the map.

The tides in Baffin Bay and in Robeson Channel consist largely of stationary waves.

One of the most remarkable results established by the Peary expedition is that the semidaily tide wave progresses eastward, and not westward, along the northern coast of Grant Land, which shows that the progressive wave from Lancaster Sound and Jones Sound, which passes west of Axel Heiberg Island, governs this tide.

The fact that the range of tide coming from the west can be as large as 0.8 foot at Point Aldrich, near Cape Columbia, indicates that land is not far distant towards the northwest.

In high latitudes the diurnal forces are large; and so if there exist a deep uninterrupted polar ocean, the diurnal tide should approximately follow the equilibrium theory for an inclosed sea. For certain arctic coasts this is the case while for others either the times or ranges depart considerably from the theoretical values.

Some of the facts tending to establish the existence of land situated between the Arctic Archipelago and the Arctic coast of eastern Siberia are as follows: (1) At Point Barrow the flood comes from the west and not from the north; (2) the range of the semidaily tide at Bennett Island is 2.5 feet while it is only 0.4 foot at Point Barrow and 0.5 foot at Flaxman Island; (3) the times of the semidaily tide on the north coast of Alaska do not indicate that the tide, propagated from the Atlantic Ocean to Alaska, crosses a deep and uninterrupted polar basin; (4) the diurnal tides at Teplitz Bay, Bennet Island, Pitlekaj, Point Barrow, and Flaxman Island have less than one half of their equilibrium values, which fact makes the supposition of an uninterrupted polar basin improbable if not impossible; (5) the westward drift of the Jeannette and the westward drift observed by Mikkelsen and Leffingwell indicate an obstruction in the polar basin. R. A. H.

TERRESTRIAL MAGNETISM.—*Directions for magnetic measurements.* D. L. Hazard. Pp. 131. Government Printing Office. 1911.

This publication aims to present the subject so that an observer familiar with the use of instruments but without experience in magnetic work may make observations for determining magnetic elements without other assistance than the book itself. The first part is devoted to definitions, explanations of principles, and the derivation of formulas. The three other sections of the book give specific directions for absolute observations on land and at sea and general directions for the operation of a magnetic observatory. At the end of the volume are standard forms of record and tables for use in computation. The volume can be easily carried in the field. R. L. Faris.

TERRESTRIAL MAGNETISM.—*Results of observations made at the Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Md., 1907 and 1908.* D. L. HAZARD. Washington, Government Printing Office, 1911. *Results of observations made at the Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska, 1907 and 1908.* D. L. HAZARD. Washington, Government Printing Office, 1911. *Results of observations made at the Coast and Geodetic Survey Magnetic Observatory near Honolulu, Hawaii, 1907 and 1908.* D. L. HAZARD. Washington, Government Printing Office, 1911.

In terrestrial magnetism the Coast and Geodetic Survey has published during this calendar year, the results of its magnetic observatory work at three of its five magnetic observatories for the years 1907 and 1908, viz: for Cheltenham, Maryland; Sitka, Alaska; and Honolulu, Hawaii. Each volume contains the results of two years observations. The hourly values of the magnetic declination, the horizontal and vertical magnetic intensity are tabulated for the whole period. The mean nourly values of these magnetic elements are given for each month as well as those for the "ten least disturbed days." Based upon the data in these tables are other tables showing the diurnal variation of the magnetic elements. A summary of monthly mean values of the different magnetic elements is also given.

The volumes also contain tabulations of the principal magnetic disturbances recorded at the observatories. The actual records of a number of these magnetic disturbances or "magnetic storms" are reproduced to three-fourths the original size, and are referred to Greenwich mean time for facility of comparison with the records of other observatories.

The magnetic data conform as far as possible with the recommendations of the Commission on Terrestrial Magnetism of the International Meteorological Committee as expressed at its several meetings since 1896.

In these volumes is also given the data of all earthquakes recorded on the seismographs operated at the magnetic observatories during 1907 and 1908.

At the present time all of the magnetic observatories of the Coast and Geodetic Survery are making special registration observations of the magnetic elements (declination, horizontal and vertical intensity) at stated periods, in response to the request of the Royal Society of London for international coöperation in magnetic work on certain term days from May, 1911, to January, 1912, covering a portion of the period of the magnetic work of the English South Polar Expedition now in the antarctic regions.

During the month of April special simultaneous registration observations were made at Cheltenham, Maryland, and at Tucson, Arizona, in coöperation with the magnetic work of Professor Birkeland at Khartum, Africa, when studying the zodiacal light. It was thought that the comparison of the magnetic curves at places so far apart might serve to decide the question of the simultaneity or non-simultaneity of the abruptly beginning magnetic storms. R. L. FARIS.

PHYSICS.—*On the computation of the constant c_2 of Planck's equation by an extension of Paschen's method of equal ordinates.* E. BUCKINGHAM and J. H. DELLINGER. Bulletin Bureau of Standards, 7: 393–406, 1911.

Planck's equation for the intensity of radiation J, of wave length λ, from a black body at the absolute temperature θ viz.

$$J = C_1 \left[\lambda^5 \left(e^{c_2/\lambda\theta} - 1 \right) \right]^{-1}$$

appears to represent very well the results of all known observations. If $\lambda\theta$ is not too large, the experimental facts are represented sufficiently well by Wien's equation:

$$J = C_1 \lambda^{-5} e^{-c_2/\lambda\theta}$$

This equation defines an optical scale of temperature, which is used for high temperature work. To make this scale fit the standard gas scale of temperature within their common range of about 650° C. to 1650° C., the constant c_2 must be known accurately. This constant may be determined by observing the distribution of energy in the spectrum of a black body at a constant temperature, giving a so-called "energy curve." From the two values of λ corresponding to equal values of J on either side of the maximum of the curve, c_2 may be calculated by an equation due to Paschen provided the observed curve is representable by Wien's equation.

This paper extends Paschen's method, in two different ways, to apply to curves for which Planck's equation must be used. The first method consists in the substitution in Paschen's equation of corrected values of the wave lengths read from the energy curve, the point of the method being in the determination of these corrections. The second method solves Planck's equation directly, obtaining an exact relation, which may be simplified by justifiable approximation to a form the same as Paschen's equation with a small correction term added. J. H. D.

PHYSICS.—*Note on the temperature scale between 100° and 500° C.* C. W. WAIDNER and G. K. BURGESS, Bulletin Bureau of Standards, 7: 1–9. 1911.

By means of resistance thermometers reading to an accuracy of 1 in 100,000 and calibrated[1] at the ice, steam, and sulphur-boiling points, using the Callendar equation, the nitrogen constant volume temperature scale in the interval 100° to 500° C. is found to be represented to better than 0.1° C. by the following freezing and boiling points:

Freezing		Boiling	
Tin	231.9	Naphthaline	218.0
Cadmium	321.0	Benzophenone	306.0
Zinc	419 4	Sulphur	444 7

G. K. B.

PHYSICS.—*On the constancy of the sulphur boiling point.* C. W. WAIDNER and G. K. BURGESS. Bulletin Bureau of Standards, 7: 127–130. 1911.

Thermocouples of platinum and other metals such as are used in high temperature measurements often give results in the sulphur boiling apparatus discordant by 1° C. or more.[2] By means of platinum-rhodium thermocouples free from inhomogeneity and notably with one of only 0.1 mm. diameter, as well as by means of a resistance thermometer of very short coil, less than 9 mm. in length and of 13.1 ohms resistance taking only 0.006 amperes measuring current, it is shown that the point to point variation in temperature within the usual form (*loc. cit.*) of sulphur boiling apparatus is less than 0.05° C. The sulphur boiling point appears to be the most exactly defined, the most certainly reproducible, and the most constant yet studied, of all the fixed temperatures given by the chemical elements. G. K. B.

PHYSICS.—*A new form of direct-reading candle-power scale and recording device for precision photometers.* G. W. MIDDLEKAUFF. Bulletin Bureau of Standards. 7: 11–44. 1911.

In precision photometry it is necessary to take a large number of readings, which, with the subsequent calculations for candle-power, are not only fatiguing but introduce the possibility of error, especially when the observer has both to read the photometer and record the settings

[1] Bulletin Bureau of Standards, 6. 149–230. 1910.
[2] Ibid., 6. 149–230. 1910.

Furthermore, the ordinary, commercial candlepower scale cannot well be adapted to precision work because it is practically impossible to so adjust the comparison lamp as to make the scale read the exact candlepower directly, especially since at least six standards should be employed in making the adjustment.

At the Bureau of Standards these difficulties are overcome by automatically recording the photometric settings by dots on a sheet of paper, or chart, containing a special printed scale which is capable of being accurately adjusted to the record. The chart is wrapped on a cylinder which rests on the bench with its axis parallel to the photometer bar. By pressing a key located on the photometer carriage a record dot is printed at the correct position on the chart for each setting, as it is made, and as the key opens, the cylinder, by means of an electrically driven secondary clock, is advanced a short distance thus preventing any two dots from coinciding and at the same time showing the order in which the readings are made. A large number of settings on a given lamp are thus made quickly and without prejudice and their mean, which corresponds to the center of mass of the cluster of record dots, is readily and accurately determined.

The special scale is rectangular in form, the upper and lower sides being graduated into linear candle-power scales corresponding, respectively, to the extreme adjustments of the comparison lamp within which it is desired to work. The points of division in these two linear scales are joined by straight lines, thus producing within the rectangle an indefinite number of linear candle-power scales, so that for any arbitrary adjustment of the comparison lamp between the limits chosen there will be a scale which will exactly fit the record printed by dots on the chart. The proper one is easily determined by preliminary readings on the standards and the values of the unknown lamps are read off to the nearest one-hundredth of a candle.

This scale is adaptable to all arrangements of the photometer and is adaptable also to the measurement, without the use of rotating sectored disks, of lamps differing considerably from one another or from the standards in candlepower; in which case, to make the record of all settings fall on the chart, the various lamps when measured are placed, respectively, according to their intensity, at different points along the photometer bar.

In each and every case the scale reads in candle-power directly, and if the values be written on the chart when they are first read from the scale it becomes a simple matter for a second reader to check the work of the first entirely by inspection. G. W. M.

INORGANIC CHEMISTRY.—*The rôle of hydrolysis in geological chemistry.* ROGERS C. WELLS. Economic Geology, **6**: 211–217. 1911.

Owing to hydrolysis most solutions that are active in geologic changes are either alkaline or acid, rarely neutral. The nature of the hydrolytic reaction for several salts is described and it is shown that geologic action may often be proportional to the concentration of hydroxyl ion in a solution even though, as with carbonates, it is a "salt" which is assumed to be present. Owing to the increasing ionization of water at high temperatures, as well as the increasing hydrolysis of salts, hydrolysis becomes extremely marked at such temperatures. This may help to explain the action of water as a "mineralizer." R. C. W.

MINERALOGY.—*The relation of bornite and chalcocite in the copper ores of the Virgilina District of North Carolina and Virginia.* FRANCIS BAKER LANEY, Geological Survey. Proceedings of the United States National Museum, No. 1835, **40**: 513–524, Pls. 63–69. 1911.

The rocks of the Virgilina District are greenstone and sericitic schists cut by granite and gabbro. The intrusive rocks show no schistosity. The schists have been derived from volcano-sedimentary rocks of two types—andesite and quartz porphyry, with tuffs corresponding to these rock types. Their age is probably early Paleozoic.

The veins have a more northerly trend than the schistosity of the country rock. Their filling is quartz with local and varying amounts of epidote and calcite. The ore-bearing veins are confined to the more basic portions of the greenstone schists, and the ore lies in well-defined shoots.

The ore minerals are bornite and chalcocite. They are chiefly in quartz, but are not confined to any one of the gangue minerals. Bornite is in slight excess over chalcocite and is apparently of only one period of deposition. Chalcocite is of two periods—one confined to the upper portions of the vein, younger than, and filling a network of minute fractures in, the bornite; the other contemporaneous and intergrown often crystallographically with it. There is no evidence that any of the bornite is secondary. It is, therefore, clear that in the Virgilina District the greater part of the chalcocite is a primary mineral contemporaneous with the bornite. F. B. L.

MINERALOGY.—*Natramblygonite, a new mineral.* WALDEMAR T. SCHALLER. American Journal of Science, **31**: 48–50. 1911.

Natramblygonite is a soda amblygonite, or a hydrofluophosphate of alumina and soda with the soda in part replaced by lithia. This mineral was found near Cañon City, Colorado, and its analysis gave the results: P_2O_5, 44.35; Al_2O_3, 33.59; Li_2O, 3.21; Na_2O, 11.23; K_2O, 0.14; H_2O, 4.78; F, 5.63; deduct O for F, 2.37; total, 100.56. W. T. S.

MINERALOGY.—*Thaumasite from Beaver County, Utah.* B. S. BUTLER and W. T. SCHALLER. American Journal of Science, **31**: 131–134. 1911.

The rare mineral thaumasite was found in veins in altered limestone in the Old Hickory mine, Rocky Range, Rocky district, Beaver Co., Utah. Its properties agree with those of thaumasite from other localities and the analysis gives the formula $3CaO.SiO_2.SO_3.CO_2.15H_2O$.

B. S. B.

MINERALOGY.—*Bismuth ochers from San Diego County, California.* WALDEMAR T. SCHALLER. Journal American Chemical Society, **33**: 162–166. 1911.

The bismuth ochers result from the oxidation of native bismuth and analyses of three samples show them to be either bismite $Bi(OH)_3$, pucherite $BiVO_4$ or mixtures of these two. It is concluded, from a study of the literature, that the anhydrous bismuth oxide, Bi_2O_3, probably does not occur in nature. W. T. S.

MINERALOGY.—*Krystallographische Notizen über Albit, Phenakit und Neptunit.* W. T. SCHALLER. Zeitschr. Kryst. Mineral., **48**: 550–558. 1911.

Some rare crystal forms are described on albite from Marin Co., California. Phenakite from New Hampshire and neptunite (new form) from California are described crystallographically. All the known forms, with coördinate angles and literature references, of phenakite and neptunite are brought together in tables. W. T. S.

GEOLOGY.—*A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska.* PHILIP S. SMITH and HENRY M. EAKIN. Bulletin U. S. Geological Survey No. 449. Pp. 141, with maps, sections, and views. 1911.

The region described extends from the Yukon River near the mouth of the Koyukuk westward to Council in Seward Peninsula. There are two

main geologic provinces—a Cretaceous basin to the east and an area occupied by metamorphic rocks to the west.

The Cretaceous rocks, which contain invertebrate fossils, cover a large area and have a thickness of more than 20,000 feet, with neither top nor bottom exposed. At the base of the Cretaceous section is the Ungalik conglomerate, at least a thousand feet thick, which grades upward, and probably laterally also, into the Shaktolik formation, of sandstones and shales. The sandstone is made up of fairly fresh feldspathic and ferromagnesian minerals. Cross bedding, concentric weathering, and mud-flat markings are common structures and some of the beds are lignitic.

The Ungalik and Shaktolik rocks are younger than the main igneous intrusives, but in a few places they are cut by dioritic rocks, and the mineralization effected by these has given rise to small placers. After deformation and erosion the Cretaceous rocks were covered by basaltic lavas.

In the region of metamorphic rocks are schists, limestones, and altered basic intrusives, all intricately folded and faulted. Fossils from the limestones are Silurian to Devonian-Carboniferous. The metamorphic rocks were intruded by granites and diorites after the main period of metamorphism but before the deposition of the Cretaceous sediments.

The metamorphic rocks are those most mineralized, and there are two series of auriferous quartz veins—one older and one later than the period of metamorphism. Neither carries considerable sulphides. These veins are the sources from which the placer deposits in the western part of the region, most notably near Council and Bluff, have been derived. P. S. S.

GEOLOGY.—*The State Geological Surveys of the United States.* Compiled under the direction of C. W. Hayes. Bulletin U. S. Geological Survey No. 465. Pp. 177. 1911.

Material compiled in coöperation with the administrative officers directing State geological surveys. Thirty-six States now have organizations for carrying on geological work.

PALEONTOLOGY.—*The fauna of the Moorefield shale of Arkansas.* George H. Girty. Bulletin U. S. Geological Survey No. 439. Pp. 148, 15 Pls. 1911.

The Moorefield shale is a member of the Mississippian section of northern Arkansas lying above the Boone formation and below the Bates-

ville sandstone. It is a series of black shales which has near Batesville a thickness of about 225 feet, but which thins rapidly in a westward direction, so that at Marshall it is less than 30 feet thick and still farther west, in the Fayetteville region, the Batesville is reported to rest directly on the Boone.

The Moorefield fauna treated in this report was obtained in the region about Batesville and at Marshall and comprises 89 species and varieties. Its facies is conspicuously different from those of the typical Mississippian faunas farther north and, as pointed out by H. S. Williams, by whom its general character was first made known, it contains a number of types which taken by themselves give it, in a measure, a Devonian aspect.

The Moorefield fauna is closely related to that of the lower portion of the Caney shale of Oklahoma and the two are regarded as being in correlation. At the same time the Moorefield shale has been generally referred to the "St. Louis group" and this assignment is probably correct. G. H. G.

PALEONTOLOGY.—*The fauna of the phosphate beds of the Park City formation in Idaho, Wyoming, and Utah.* GEORGE H. GIRTY. Bulletin U. S. Geological Survey No. 436. Pp. 8, Pls. 7. 1911.

It is important to note that although this report bears date of 1910, its actual publication did not take place until early in the following year.

The Park City formation, named from Park City in the Wasatch Mountains of northeastern Utah, has been traced northward into Idaho, from which region the collections discussed in this report were largely made. Most of them came from the vicinity of Montpelier and of Raymond Canyon.

In this region the formation consists of two limestone members separated by a bed of dark shale about 100 feet in thickness. It is in this shale that the phosphate deposits of the Utah-Idaho-Wyoming district occur. The fossils are found chiefly in a few thin limestone sheets by which the shales are divided and especially in what is locally known as the "Cap lime," a ledge of earthy limestone about 2 feet in thickness which at Montpelier comes in near the base of the black shales just above the main phosphate bed. The fauna thus far obtained consists of 45 species and is unique in character being, like so many of our western faunas, unlike the Upper Carboniferous of the Mississippi Valley and comparable with the faunas of Asia and eastern Russia. In this report it is provisionally placed in the Pennsylvanian, but more recent data indicate that it should probably be classed as Permian. G. H. G.

FORESTRY.—*The preservative treatment of poles.* Compiled by WILLIAM H. KEMPFER. Forest Service Bulletin No. 84. Pp. 55, with plates and diagrams. 1911.

Present knowledge of the results of the creosote treatment of wooden poles is based largely on treatments made by the pressure method, using from 8 to 12 pounds, or more, of creosote to a cubic foot of timber. The expense incident to such treatment has been the chief hindrance to its more general adoption for poles. Investigations of the Forest Service have therefore been concerned with treatments which could be applied locally without the erection of elaborate and extensive plants. Much attention has also been given to the seasoning of poles, since proper seasoning not only prepares poles to receive the preservative, but under certain conditions may be in itself a means of increasing their durability.

Seasoning of poles reduces their weight usually from 16 to 30 per cent, and even more for some species. In general, poles cut during the spring and summer lose weight most rapidly; those cut during the autumn and winter lose less rapidly, but more regularly.

Preservative applied to the surface of a pole by a brush may add from one to two years to the life of timber, but permanent protection should not be expected from the application of so small a quantity of preservative. If the butt be more deeply impregnated, the life of the pole will probably be limited by the life of the top rather than by that of the butt. A life of 20 years for butt-treated chestnut and western cedar, and 22 years for northern white cedar poles is believed to be a conservative estimate. In the drier western climate butt-treated pine poles can probably be depended on to give 20 years' service.

Impregnation of many pole timbers may be accomplished in open tanks, without the use of artificial pressure, by immersion in hot and cold preservatives, the cold following the hot. The open tank process has the advantage that it is possible to apply the preservative to the butts only, with a great saving in the creosote. FINDLEY BURNS.

FORESTRY—*Chaparral: Studies in the dwarf forests, or elfin-wood, of Southern California.* FRED G. PLUMMER. Forest Service Bulletin No. 85. Pp. 50, with map, plates, and text figures. 1911.

True chaparral is a type of plant formation which occurs in several widely separated parts of the world. In the United States it is found in southern California over an area of about 5,500,000 acres, along the axis of the Sierra for a distance of about 450 miles. The formation is known to plant ecologists as sclerophyllous woodland, and has many local

names, such as scrub, elfin-wood, bush-forest, heath-scrub, maqui, shrub, steppe, etc. It may be described (though not defined) as a mixed forest of stunted trees, the result of peculiar climatic conditions, such as deficiency of moisture, excessive transpiration, barren soil, high altitude, and wind.

The economic importance of chaparral is due chiefly to the necessity of watershed protection in a region where water is scarce and is of the utmost importance for irrigation and municipal supply. In southern California chaparral protects about three-fourths of the upper watersheds of the streams along the coast. It serves to conserve and regulate the flow of streams in two ways: (1) By the root systems which penetrate the soil and assist the water to percolate, while they prevent erosion; and (2) by lessening the evaporation.

In the chaparral, as it now exists, those species best suited for cover are not the most numerous. The growth of the better sorts should be encouraged, and possibly some foreign species should be introduced.

F. G. P.

FISHERIES.—*The food value of sea mussels.* Irving A. Field, U. S. Fisheries Laboratory, Woods Hole. Bulletin of the Bureau of Fisheries, 29: 85–128. Pls. 18–25, figs. 2. 1911.

Sea mussels (*Mytilus edulis*) are so palatable and nutritious, and are likewise so abundant and available, that to neglect them for table use is waste. They are found along the coasts of practically all the northern half of the Northern Hemisphere, and in the slightly brackish bays and estuaries of New Jersey, Long Island, Rhode Island, and Massachusetts they exist in beds so extensive that they can be collected daily by the ton. Many have pronounced them equal or superior in flavor to the oyster, and obviously to the coastal population they would be a cheap food. They are, moreover, in season when the oyster is out of season, they breed prolifically, and, requiring less special conditions for growth than does the oyster, they may be more easily cultivated.

The readiness with which mussels spoil is the one difficulty in marketing them raw, for they must be used within 24 hours after being taken from the water. Dr. Field finds, however, that canned or pickled they will retain the natural flavor for months. He describes preserving methods, developed by his experiments, and appends a number of recipes for preparing mussels for the table.

While the main purpose of the report is practical and directed to the encouragement of an industry new to America, a large part of Dr. Field's

text is devoted to the natural history of the mussel, and includes chapters describing experiments by Dr. C. L. Alsberg to determine the available protein in the mussel meats, and by Dr. Donald Van Slyke, assisted by Messrs. W. M. Clark and C. B. Bennett, to determine the rate of digestion and proportion of nutriment absorbed from cooked mussels and squid compared with beef as a standard. E. M. SMITH.

FISHERIES.—*The fisheries of Alaska in 1910.* M. C. MARSH and JOHN N. COBB. Bureau of Fisheries, Document 746. Pp. 72. 1911.

While the original duties of the Alaska fisheries service related entirely to the enforcement of the salmon fishery laws, the scope of its usefulness, and consequently of the agents' reports, has widened to include not only operations and statistics but observations of all conditions affecting all Alaska fisheries and, with the exception of the fur seals on the Pribilof Islands, the capture of all fur-bearing animals in Alaska as well. An important feature of the work in relation to the salmon is a series of investigations designed to throw light on the biological phenomena of the spawning runs.

Wood and Nushagak rivers, in the Bristol Bay region, were closed to all fishing in 1908, in which year, with coöperation of the packers, plans were made for a count of the salmon which reached the spawning grounds in Wood River. For this purpose a rack was constructed at the foot of Lake Aleknagik, at the headwaters of the river, in such manner that all arriving fish must pass through a gate sufficiently small to permit of an accurate record of their numbers. These figures, with the known catch in Nushagak Bay, outside the mouth of Wood River, furnish a census of the run and hence significant information as to the increment of salmon from natural spawning. Carried through several years already and to be continued for several years more, such counts are expected to afford definite scientific basis for regulation of the salmon fishery. Observations so far indicate that the Nushagak fisheries will be maintained at their present ample productiveness if 30 per cent of the run reaches the spawning grounds. E. M. SMITH.

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Underground-Water Papers, 1910. Water-Supply Papers, U. S. Geological Survey, No. 258. Pp. 1–123, with maps and figures. 1911. Includes the following separate papers: *Introduction,* W. C. MENDENHALL; *Drainage by wells,* M. L. FULLER; *Freezing of wells and related phenomena,* M. L. FULLER; *Occurrence and composition of well waters in the slates of Maine,* F. G. CLAPP; *Occurrence and composition of well waters in the granites of New England,* F. G. CLAPP; *Pollution of underground waters in limestone,* G. C. MATSON; *Protection of shallow wells in sandy deposits,* M. L. FULLER; *Composition of mineral springs in Maine,* F. G. CLAPP; *Saline artesian waters of the Atlantic Coastal Plain,* SAMUEL SANFORD; *Magnetic wells,* M. L. FULLER; *Underground waters near Manassas, Va.,* F. G. CLAPP; *The utilization of the underflow near St. Francis, Kan.,* H. C. WOLFF.

Well-drilling methods. ISAIAH BOWMAN. Water-Supply Paper, U. S. Geological Survey, No. 257. Pp. 139. Pls. four, 25 text figures. 1911.

ENGINEERING.—*Results of spirit leveling in the State of Washington, 1896 to 1910, inclusive.* R. B. MARSHALL. Bulletin U. S. Geological Survey, No. 457. Pp. 108. 1911.

Results of spirit leveling in Minnesota, 1897 to 1910, inclusive, R. B. MARSHALL. Bulletin U. S. Geological Survey, No. 453. Pp. 39. 1911.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

At the 239th meeting, at the Cosmos Club, February 8, 1911, Prof. Frank Leverett upon invitation presented an informal communication on the investigations of glacial geology that have been carried on in Minnesota during the past year.

Some exceptional conditions of petroleum accumulation. C. W. Hayes. No abstract.

The scheelite deposits at Atolia, California. F. L. Hess. No abstract.

Some features of graphite in the United States. Edson S. Bastin.

This paper was devoted largely to a description of certain graphite deposits of the Adirondack Region in New York. Geological and chemical evidence was advanced to show that some of them were formed by the dynamic metamorphism of carbonaceous sediments and that others, notably the deposit at Lead Hill near Ticonderoga, were formed by dynamic metamorphism succeeded by igneous metamorphism. Evidence was given that the graphite at Lead Hill crystallized at temperatures below 575° C. Most of the material of this paper is published in *Economic Geology*, Vol. V, pp. 134–157, 1910.

The 240th meeting, held in the Cosmos Club, February 22, 1911, was devoted to a discussion on the subject, *Geographical descriptions in geological publications.*

The program opened with an address by Prof. William Morris Davis, who contended for the adoption of a systematic method of geographical description such as would speak in terms of physiographic history. This address was followed by a discussion, in which the following members took part: M. R. Campbell, A. H. Brooks, Sydney Paige, Whitman Cross, Miss Jennie T. Martin, H. M. Eakin, David White, H. E. Gregory, G. O. Smith and W. M. Davis. ROBERT ANDERSON, *Secretary.*

At the 241st meeting, held in the Cosmos Club, March 8, 1911, Mr. L. D. Burling described a method by means of which very clear results can be obtained in photographing fossils and other opaque objects by reflected light, and photographs were exhibited. Dr. C. D. Walcott exhibited and described lantern slides of panoramic views obtained in the Glacier National Park and in adjacent portions of Canada.

General description of the Glacier National Park, Montana. M. R. Campbell.

The glaciers and glacial sculpture of the Park. F. E. Matthes. Both papers were illustrated. EDSON S. BASTIN, *Secretary.*

The 242nd meeting was held in the Cosmos Club, March 22, 1911.

REGULAR PROGRAM

The stability ranges of minerals with special reference to the geologic thermometer scale. Fred E. Wright.

The physico-chemical systems represented by rocks and the geologic forces which act upon these systems are often so complex that it is not possible at present to solve completely the problems which they present and to state definitely the behaviour of any particular rock or magma under the different conditions of temperature and pressure which may arise. It is important, therefore, that limits of temperature and pressure be established, beyond which any given system or any component of the system is no longer stable but undergoes change. These limits mark points on the geologic thermometer scale or pressure gauge and place definite boundaries to the region in which the observed reactions have taken place. At these points an abrupt shift in the equilibrium of the system occurs and produces profound changes in the system.

The most important thermometric points which may be of service in this connection are: (a) Enantiotropic inversion temperatures of minerals, as that of α quartz into β quartz; (b) temperature limits beyond which monotropic or isomeric forms cannot exist, as the temperature 450°, above which marcasite passes at atmospheric pressure into pyrite; (c) stability ranges of enantiotropic forms and of minerals which dissociate or decompose at higher temperatures, as the dissociation temperatures, for different pressures, of calcite and other carbonates or of certain of the garnets and many other contact minerals; (d) melting temperatures of stable minerals and of eutectics; (e) temperatures beyond which any physical property acquires a permanent set and by virtue of internal friction or other cause does not revert to its original state on cooling. In applying these data of laboratory experiment to geologic problems, it is important to note the conditions under which the data were obtained and the effect which other conditions of pressure or solution may have exerted on the observed points of equilibrium change.

Physiographic studies on the south slope of the San Juan Mountains, Colo. Wallace W. Atwood.

The glacial features on the south slope of the San Juan range do not differ from those which have been described by various writers in the high mountains of the West. Moraines of two epochs have been recognized and outwash deposits are associated with each. On ridges above the limit of ice action are certain gravel-strewn surfaces, which, if extended, would form a plain with gently rolling topography. This plain, sloping away from the range, would show distinct down warping at its base, and merge with the upland surfaces of the neighboring plateaus. These gravel-strewn upland surfaces are probably portions of a deformed peneplain. Beyond the mountains in the plateau district the peneplain

surfaces are mantled by a heavy deposit of bowlder-gravels. The bowlders range from one to five feet in diameter and extend at least fifty miles from the base of the range. Even at that distance some of the bowlders are three feet in diameter. These deposits are interpreted as portions of alluvial fans spread out upon the plateaus about the margin of the San Juan dome, following the redoming of that area and the associated deformation of the peneplain. Subsequently to the laying down of these gravels there were at least two distinct stages in the dissection of the plateau prior to glaciation. The earlier of these has been called the Bowlder-mesa stage. During that time broad areas were reduced to the local base level of erosion and strewn with vast quantities of gravels. The later stage has been called the Oxford stage. During this period the areas of softer rocks were reduced to late maturity or early old age in erosion topography. In the Bowlder-mesa and Oxford stages the mountain canyons were deepened and widened and remnants of these ancient valleys appear to-day as benches in the mountain canyons. Succeeding these erosion intervals, associated with which there were evidently periods of mountain growth in the San Juan region, was the glacial period. During the glacial or inter-glacial epochs mountain growth probably continued and there is reason to believe that some movement occurred after the disappearance of the last glacier.

Geological features bearing on the construction of the Panama Canal. C. W. Hayes.

This paper reported the results of a brief visit to the Canal Zone made for the purpose of determining the cause of and possible remedy for slides occurring in the side walls of the canal, which were giving much trouble to the engineers in charge.

In general the side slope practicable in any excavation depends on (1) depth, (2) character of materials, and (3) geological structure. Examination of the cut indicates that serious difficulty through failure of slopes will be experienced only in the section between Empire and Pedro Miguel. Small slides will occur outside of this section, as at La Pita, but they are due to exceptional conditions and will be relatively unimportant.

Within the section defined above are four classes of materials: (1) *Sedimentary rocks:* This class includes (a) volcanic agglomerates ejected from volcanoes in the form of angular fragments varying in size from the finest dust to several inches in diameter; deposited in water but very imperfectly bedded; generally bluish green; moderately hard when first exposed but crumbling rapidly in contact with the air. (b) Fine blue, red or black clays, composed largely of volcanic dust which has been transported and deposited by water and is well bedded; like the agglomerate, moderately hard when first exposed, but crumbling even more rapidly in contact with the air. (c) Lignite coal or black carbonaceous clay; beds one to three feet thick interstratified with (b). These beds (a), (b) and (c) with some unimportant sandstones and limestones constitute the Culebra formation of Tertiary age. (2) *Intrusive igneous rocks:* These are chiefly large masses of dark andesitic rock which

have been forced upward into the sedimentary beds, in some cases in a fluid condition but more generally after having solidified. The intrusion was accompanied by tilting and crushing of the once horizontal sedimentary beds. The andesite is generally intersected by numerous joints, but does not disintegrate readily on exposure, and where supported below will stand in vertical slopes. Gold Hill and Contractor Hill are examples of these andesitic intrusive masses. All the other high hills in the Culebra section of the Zone are apparently due to the presence of similar rocks. (3) *Lava flows:* A flow of light gray trachytic lava, 20 to 30 feet thick, is conformably interbedded with the Culebra clays throughout the central portion of the cut. The trachyte does not disintegrate readily, but by reason of its abundant joints it affords no support to the clays above. (4) *Residual clays:* The rocks in this region are deeply weathered and the original surface is covered with residual clay, derived directly from the rocks on which it rests. It is thinnest over the intrusive andesites, which decay less rapidly than the sedimentary rocks, and is thickest over those sedimentary rocks that have been so fractured as to permit the easy percolation of water.

The original "three on two" slopes have failed to stand at numerous points. Varying conditions have given rise to three classes of failures which may be designated (1) surface flows; (2) structural breaks; (3) surface disintegration.

Wherever the residual clay rests on an inclined rock surface and the lateral support is removed, as when a trench is excavated, a portion of the mass tends to flow. The material has no cohesion and very slight adhesion to the underlying rock. It acts like a viscous fluid and may flow on slopes as low as one on seven or eight. Having started it may gather sufficient momentum to carry down portions of the underlying unweathered rock, particularly if the latter is much fractured. The Cucaracha and Paraiso slides are of this type.

Every variety of rock has a limiting strength beyond which it crushes or flows. The crushing strength varies between wide limits and is lowered when one or more sides of the block are unsupported. The weakest member in the sedimentary series in the Culebra Cut is the lignite or lignitic clay. When lateral support is removed from a lignite bed it tends to give way under the overlying weight and a slide results. This may occur if the weak bed is merely unloaded by excavating, in which case it bulges up in the excavation. This type has occurred at various points between Empire and Cold Hill and in nearly every case the immediate cause appears to be the failure of a lignite bed in consequence of excavation. These structural breaks offer more serious difficulties than the surface flows, and the obvious prevention is to make the slopes sufficiently low so that the weakest rock is not loaded beyond its crushing strength. In the section of the canal threatened by slides of this type *less material will have to be removed if the slopes are lowered before the break occurs.*

As previously stated, all the sedimentary rocks of this region disintegrate rapidly when exposed to the air. They first crumble into small angular fragments and eventually into the finest powder. Slopes cut

in such rocks rapidly disintegrate and crumble until they reach an angle on which the products of disintegration will form a protective mantle. Vegetation greatly assists in this protection. While the failure of the canal slopes from this cause will not be a serious matter, it will involve the removal of a large amount of material in the aggregate and necessitate constant attention for a long time. Under certain conditions this surface disintegration becomes a more serious matter. For example, the contact between the intrusive andesite of Contractor Hill and the sedimentary clays, dips away from the canal at an angle of 55°. The crumbling of the clays below the contact leaves the andesite mass overhanging, and the overhang will increase as the canal is deepened and as more clay is exposed. With a rock so fractured as the andesite this condition is unsafe and the exposed surface of the underlying clay should be protected from further disintegration by a layer of concrete.

ROBERT ANDERSON, *Secretary.*